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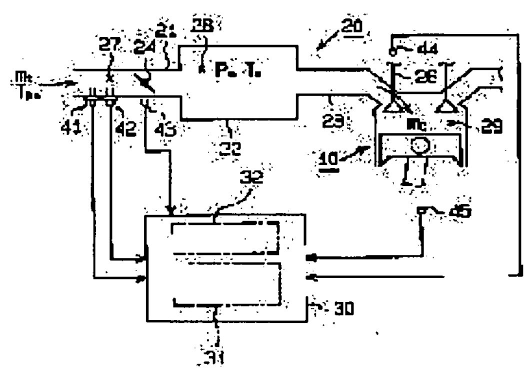
(54) INTAKE AIR FLOW ESTIMATE DEVICE FOR INTERNAL COMBUSTION ENGINE

(57)Abstract:
PROBLEM TO BE SOLVED: To estimate the intake air flow introduced in a combustion chamber through an intake passage precisely regardless of an engine operation state.
SOLUTION: The calculation device 30 of an internal combustion engine 10 estimates the temperature after the prescribed term from the present point of time of the intake air staying on the down streamside part 28 than the throttle valve 24 of the intake passage 20 based on the fluid model regarding the intake air in an intake passage 20 and the temperature information at the present point of time of the intake air. The calculation device 30 estimates the intake air flow introduced in the combustion chamber 29 from the downstream part 28 after the prescribed term from the present point of time while reflecting the estimation result.



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* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] In the inhalation air content prediction equipment of the internal combustion engine which adjusts the amount of the inhalation air introduced into a combustion chamber by the throttle valve of an inhalation-of-air path To the inhalation air in said inhalation-of-air path The related fluid model The temperature information on this time of this inhalation air The amount of the inhalation air introduced into said combustion chamber from said downstream part in a predetermined period from this time, presuming the temperature after a predetermined period from this time of the inhalation air which is alike, is based and exists in the part of the downstream rather than said throttle valve of said inhalation-of-air path, and reflecting this presumed result Inhalation air content prediction equipment of the internal combustion engine characterized by having a prediction means to predict.

[Claim 2] In the inhalation air content prediction equipment of an internal combustion engine according to claim 1 said prediction means The fluid model built by the heat energy conservation law list about the inhalation air of said downstream part based on the conservation of mass, Based on the pressure and temperature in this time of inhalation air of said downstream part, the pressure and temperature after a predetermined period are presumed from this time of the inhalation air of said downstream part in the amount in this time and temperature of the inhalation air which flows into said downstream part, and a list. Inhalation air content prediction equipment of the internal combustion engine characterized by being what predicts said inhalation air content based on the this pressure presumed and temperature.

[Claim 3] In the inhalation air content prediction equipment of an internal combustion engine according to claim 2 said prediction means mt (0) and temperature for the amount in this time of the inhalation air which flows into said downstream part Tha, Pm (0) and temperature for the pressure in this time of the inhalation air of said downstream part Tm (0), When the ratio of specific beat of mc (i) and air is set to kappa and the volume of R and said downstream part is set [the amount of the inhalation air introduced into a combustion chamber from said downstream part] to V for a gas constant, The pressure Pm (i) of the inhalation air of the discrete formula (1) obtained from said each conservation law, (2) and said inhalation air content mc (i), and said downstream part, and relational expression with temperature Tm (i) (3)

[Equation 1]

$$P_m(i) = P_m(i-1) + \Delta t \cdot \kappa \cdot \frac{R}{V} \cdot \left(m_t(i-1) \cdot T_{ha} - m_c(i-1) \cdot T_m(i-1)\right) \cdots (1)$$

$$\frac{P_m}{T_m}(i) = \frac{P_m}{T_m}(i-1) + \Delta t \cdot \frac{R}{V} \cdot \left(m_t(i-1) - m_c(i-1)\right) \cdots (2)$$

$$m_c(i) = f\left(P_m(i), T_m(i)\right) \cdots (3)$$

$i = 1$〜nの整数

Δt: 離散間隔 $tfwd = \sum_{i=1}^{n} (\Delta t(i))$

$f\left(P_m(i), T_m(i)\right)$: $P_m(i), T_m(i)$についての関数

Inhalation air content prediction equipment of the internal combustion engine characterized by being what presumes the pressure Pm (n) and temperature Tm (n) after the predetermined period tfwd from this time of the inhalation air of said downstream part by performing processing only whose count n of predetermined it is alike and repeats the based operation.

[Claim 4] In the inhalation air content prediction equipment of an internal combustion engine according to claim 3 said prediction means Perform said a series of repetitive operation for every predetermined interrupt

period, and it sets to this interrupt timing. Inhalation air content prediction equipment of the internal combustion engine characterized by being what computes either [at least] the pressure Pm in this time of the inhalation air of said downstream part used for the repetitive operation in next interrupt timing (0), or the temperature Tm (0).

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* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the inhalation air content prediction equipment of the internal combustion engine which predicts the amount of the inhalation air introduced into an engine combustion chamber.
[0002]
[Description of the Prior Art] In case the amount (inhalation air content) of the air introduced into an internal combustion engine's combustion chamber through an inhalation-of-air path determines the controlled variable of internal combustion engines, such as fuel-injection control and ignition timing control, as what reflects engine operational status most with an engine rotational frequency, it is used, and this is usually called for based on the detecting signal from an air flow meter or an intake-pressure sensor prepared in the inhalation-of-air path.
[0003] By the way, it faces computing an internal combustion engine's controlled variable based on an inhalation air content, and if the inhalation air content in this time called for from detecting signals, such as an air flow meter, is used as it is, and it is at the time of transient operation, this controlled variable will come to be determined based on a different inhalation air content from the time of the controlled variable actually being reflected in engine control. Thus, if the inhalation air content used for the decision of a controlled variable differs from the inhalation air content in case the controlled variable is reflected in engine control, control adapted to actual engine operational status cannot be performed, but even if it raises the control precision, a limitation will come to be generated naturally.
[0004] Then, the inhalation air content after a predetermined period is predicted from this time, and the equipment which determined the controlled variable based on the forecast is conventionally proposed so that it may be indicated by JP,2-42160,A. By performing such prediction, the inhalation air content at the time of a controlled variable being reflected in engine control can be foreseen beforehand, this controlled variable can be determined now, and improvement in control precision comes to be achieved.
[0005] Moreover, an inhalation air content changes also with an engine rotational frequency, or intake-air temperatures besides the opening of a throttle valve. For example, since the consistency of inhalation air becomes large so that an intake-air temperature becomes low, an inhalation air content also comes to increase. Therefore, in case an inhalation air content is predicted as mentioned above, it becomes important when obtaining a prediction result accurate [also taking into consideration the effect of such an intake-air temperature].
[0006] He detects the intake-air temperature in the location of the upstream, and is trying to make that intake-air temperature (for this to be hereafter, called "upstream intake-air temperature", when it is necessary to distinguish especially from the intake-air temperature in other locations of an inhalation-of-air path) reflect in prediction of an inhalation air content rather than the throttle valve of an inhalation-of-air path with this point and the above-mentioned equipment.
[0007]
[Problem(s) to be Solved by the Invention] However, although the above-mentioned conventional equipment is making the intake-air temperature reflect in prediction of an inhalation air content, it cannot but perform the prediction to the last by making for location-change and its time change of an intake-air temperature not to arise during a prediction period in an inhalation-of-air path into a prerequisite.
[0008] If surely it was at the time of steady operation by which the opening of a throttle valve is held uniformly, since it was in the range which most location - change of the intake-air temperature in such an inhalation-of-air path does not have, and can also disregard change of a time intake-air temperature, though

the inhalation air content was predicted under the above-mentioned prerequisite (i.e., ****** [only based on the upstream intake-air temperature mentioned above, it predicts an inhalation air content]), gross errors do not arise in the prediction result.
[0009] However, if it is when the opening of a throttle valve changes rapidly at the time of transient operation, intake-air temperatures come to differ according to the location in an inhalation-of-air path, and the time change cannot be disregarded greatly, either. Therefore, the above-mentioned prerequisite does not meet the actual temperature condition of the inhalation air in such an inhalation-of-air path.
[0010] For example, when the amount of the inhalation air which flows into the downstream part of this valve when the opening of a throttle valve increases increases rapidly, the inhalation air of this downstream part will be compressed and the temperature (henceforth a "downstream intake-air temperature") will come to rise more temporarily than the upstream intake-air temperature mentioned above. Since it will be conversely expanded by the inhalation air of this downstream part when the amount of the inhalation air which flows into said downstream part on the other hand when the opening of a throttle valve decreases decreases rapidly, a downstream intake-air temperature comes to fall more temporarily than an upstream intake-air temperature.
[0011] thus, temporary, if it is at the time of transient operation from which the opening of a throttle valve changes -- an imitation -- a downstream intake-air temperature can become temperature which is changed sharply in time and is different from an upstream intake-air temperature. Consequently, if it is in the conventional equipment which predicts by making for change [be / location-/ it / time] of an intake-air temperature not to arise in an inhalation-of-air path into a prerequisite, so to speak, the effect by the dynamic behavior of the intake-air temperature at the time of such transient operation is not reflected in prediction of an inhalation air content, therefore the error of the prediction result cannot be disregarded, either.
[0012] This invention is made in view of such the actual condition, and that purpose is in offering the inhalation air content prediction equipment of the internal combustion engine which can predict the amount of the inhalation air introduced into a combustion chamber through an inhalation-of-air path with a sufficient precision even if it is at the transient operation time.
[0013]
[Means for Solving the Problem] The means and its operation effectiveness for attaining the above-mentioned purpose are indicated below. In the inhalation air content prediction equipment of the internal combustion engine which adjusts the amount of the inhalation air with which invention indicated to claim 1 is introduced into a combustion chamber by the throttle valve of an inhalation-of-air path To the inhalation air in said inhalation-of-air path The related fluid model The temperature information on this time of this inhalation air The amount of the inhalation air introduced into said combustion chamber from said downstream part in a predetermined period from this time, presuming the temperature after a predetermined period from this time of the inhalation air which is alike, is based and exists in the part of the downstream rather than said throttle valve of said inhalation-of-air path, and reflecting this presumed result He is trying to have a prediction means to predict.
[0014] A prediction means presumes the temperature of the inhalation air of said downstream part based on the fluid model about the inhalation air in an inhalation-of-air path, and the temperature information (physical quantity which has these or correlation, such as a mode of temperature or a temperature change) on this time of this inhalation air, and makes the presumed result reflect in prediction of an inhalation air content in the above-mentioned configuration. Therefore, even if it is the case where the temperature of this downstream part changes from this time transitionally, when that transitional change has been grasped, an inhalation air content can be predicted, and a very accurate prediction result can be obtained.
[0015] Moreover, since the amount of the inhalation air introduced into a combustion chamber through an inhalation-of-air path tends to increase, so that the pressure of the inhalation air of the above-mentioned downstream part becomes high, and so that the temperature becomes low, it can ask for this based on the above-mentioned pressure and temperature. Therefore, the amount of the inhalation air introduced into a combustion chamber in a predetermined period from this time based on the pressure and temperature which are they-presumed can be predicted now by presuming the pressure and temperature after a predetermined period from this time of the inhalation air of a downstream part.
[0016] Furthermore, the pressure and temperature after a predetermined period can presume these from this time of the inhalation air of this downstream part by relating with physical quantity called the pressure and temperature of inhalation air in this time of that downstream part at the amount in this time and temperature of the inhalation air which flows into a downstream part at the heat energy conservation law list about the inhalation air of a downstream part based on the conservation of mass, and a list.

[0017] Invention indicated to claim 1 is set to the above-mentioned inhalation air content prediction equipment as a configuration materialized more like invention which indicated to claim 2. Therefore, the -aforementioned prediction means The fluid model built by the heat energy conservation law list about the inhalation air of said downstream part based on the conservation of mass, Based on the pressure and temperature in this time of inhalation air of said downstream part, the pressure and temperature after a predetermined period are presumed from this time of the inhalation air of said downstream part in the amount in this time and temperature of the inhalation air which flows into said downstream part, and a list. The configuration that it is what predicts said inhalation air content based on the this pressure presumed and temperature is employable.
[0018] Invention indicated to claim 3 is set to the inhalation air content prediction equipment of an internal combustion engine according to claim 2. Moreover, said prediction means mt (0) and temperature for the amount in this time of the inhalation air which flows into said downstream part Tha, Pm (0) and temperature for the pressure in this time of the inhalation air of said downstream part Tm (0), When the ratio of specific beat of mc (i) and air is set to kappa and the volume of R and said downstream part is set [the amount of the inhalation air introduced into a combustion chamber from said downstream part] to V for a gas constant, The pressure Pm (i) of the inhalation air of the discrete formula (1) obtained from said each conservation law, (2) and said inhalation air content mc (i), and said downstream part, and relational expression with temperature Tm (i) (3)
[0019]
[Equation 2]

$$P_m(i) = P_m(i-1) + \Delta t \cdot \kappa \cdot \frac{R}{V} \cdot \left(m_t(i-1) \cdot T_{ha} - m_c(i-1) \cdot T_m(i-1)\right) \cdots (1)$$

$$\frac{P_m}{T_m}(i) = \frac{P_m}{T_m}(i-1) + \Delta t \cdot \frac{R}{V} \cdot \left(m_t(i-1) - m_c(i-1)\right) \cdots (2)$$

$$m_c(i) = f\left(P_m(i), T_m(i)\right) \cdots (3)$$

$i = 1$〜nの整数

Δt: 離散間隔 $tfwd = \sum_{i=1}^{n} (\Delta t(i))$

$f\left(P_m(i), T_m(i)\right)$: $P_m(i)$, $T_m(i)$についての関数

By performing processing only whose count n of predetermined it is alike and repeats the based operation, it is supposed that it is what presumes the pressure Pm (n) and temperature Tm (n) after the predetermined period tfwd from this time of the inhalation air of said downstream part.
[0020] Since according to the above-mentioned configuration it is discretized and expressed as said fluid model is shown in each above-mentioned formula (1) and (2), the pressure Pm (n) and temperature Tm (n) after a predetermined period can be presumed based on a comparatively easy algorithm from this time of the inhalation air of said downstream part.
[0021] It sets to the inhalation air content prediction equipment of an internal combustion engine according to claim 3 like [in performing such data processing] invention indicated to claim 4. Moreover, the -aforementioned prediction means Perform said a series of repetitive operation for every predetermined interrupt period, and it sets to this interrupt timing. If the configuration that it is what computes either [at least] the pressure Pm in this time of the inhalation air of said downstream part used for the repetitive operation in next interrupt timing (0) or the temperature Tm (0) is adopted Not using a sensor etc., ** can also search for serially the pressure Pm of the above-mentioned inhalation air (0), or its temperature Tm (0) through the above-mentioned repetitive operation, and simplification of the configuration of inhalation air content prediction equipment can be attained now.
[0022] Moreover, generally, since the responsibility of a general-purpose temperature sensor is low, when the temperature Tm of inhalation air (0) is detected using this sensor, it is difficult to detect change of this temperature Tm (0) with a sufficient precision, and it cannot finish being avoided that an error arises in the detection result.
[0023] In this point and the above-mentioned configuration, if especially the temperature Tm of an inhalation air content (0) is computed, while being able to attain simplification of a configuration, the fall of the predictability resulting from the detection error of such a sensor can be avoided.
[0024]
[Embodiment of the Invention] The 1st operation gestalt of this invention is explained below [the 1st

operation gestalt].

[0025] He is trying to apply the inhalation air content prediction equipment concerning this invention to the internal combustion engine which has an air flow meter as a sensor which detects an inhalation air content with this operation gestalt. First, with reference to drawing 1 , this internal combustion engine's 10 outline and the configuration of this prediction equipment are explained.

[0026] An internal combustion engine's 10 inhalation-of-air path 20 is constituted by the suction-port 23 grade which connects the surge tank 22 connected to the aisleway of a throttle body 21 in which the throttle valve 24 was formed, and the downstream of this throttle body 21 and this surge tank 22, and a combustion chamber 29. After metering of the inhalation air which flows the inhalation-of-air path 20 is carried out by the throttle valve 24, it is introduced in a combustion chamber 29 at the time of valve opening of an inlet valve 26.

[0027] Inhalation air content prediction equipment predicts the amount of the inhalation air introduced in a combustion chamber 29 in a predetermined period from this time, and is greatly constituted by the various sensors 41-45 including an arithmetic unit 30 and an air flow meter 41.

[0028] The arithmetic unit 30 is equipped with the operation part 31 which performs data processing, and the memory 32 the various function data used on the occasion of the program concerning such data processing or its activation were remembered to be. This arithmetic unit 30 is constituted by the electronic control which performs various control of an internal combustion engine 10.

[0029] Others, an intake temperature sensor 42, the throttle sensor 43, the cam angle sensor 44, and crank angle sensor 45 grade are contained in sensors 41-45. [air flow meter / 41 / above-mentioned] All, the air flow meter 41 and the intake temperature sensor 42 are formed in the part of the upstream from the throttle valve 24 at the inhalation-of-air path 20, and detect the amount and temperature of the inhalation air which flows in a surge tank 22 through this valve 24 (henceforth "the upstream intake-air temperature Tha"), respectively.

[0030] Moreover, with this operation gestalt, the thing of the heat ray type equipped with the detecting element 410 which consists of a heat ray as the above-mentioned air flow meter 41 is used. Drawing 2 shows the cross-section structure of this detecting element 410. As shown in this drawing, this detecting element 410 is constituted by the heat ray 412 which consists of platinum etc., and the glass layer 414 which covers the perimeter of this heat ray 412.

[0031] The throttle sensor 43 is formed near the throttle valve 24, and detects the opening (throttle opening TA) of this valve 24. The crank angle sensor 45 is formed [near / where the cam angle sensor 44 carries out the closing motion drive of the inlet valve 26 / the cam shaft (illustration abbreviation)], respectively near the crankshaft (illustration abbreviation) which carries out the rotation drive of this cam shaft. An arithmetic unit 30 incorporates the output signal of these cam angle sensor 44 and the crank angle sensor 45, and detects the closing motion stage (valve timing VT) of an inlet valve 26, respectively in the rotational speed (engine engine speed NE) and its rotation phase (crank angle CA) list of a crankshaft. In addition, the device (illustration abbreviation) in which the closing motion stage of the above-mentioned inlet valve 26 is changed based on engine operational status, such as the engine rotational frequency NE and an engine load, is prepared for the internal combustion engine 10 of this operation gestalt. Therefore, the above-mentioned valve timing VT will be suitably changed according to engine operational status.

[0032] Next, prediction processing of the inhalation air content by the equipment of such this operation gestalt is explained. The principle which will be the requisite for this prediction processing first is explained.

[0033] The space from the inhalation-of-air path 20 to a combustion chamber 29 from a throttle valve 24 First, the part of the upstream From 27 and this throttle valve 24, rather than an inlet valve 26 by the downstream The part of the upstream (It is hereafter called an "upstream part") (It is hereafter called a "downstream part") It divides into 28 and three parts called a combustion chamber 29, and the fluid model about the inhalation air which exists in the downstream part 28 among each [these] parts 27-29 is built.

[0034] Namely, the amount of the inhalation air which flows out of "M" and this downstream part 28 the mass of the inhalation air which exists in this downstream part 28 in a combustion chamber 29 per time amount If the amount (henceforth "throttle-valve through put") of the inhalation air which flows (it is hereafter called "the inhalation air content in a cylinder") into the downstream part 28 from "mc" and the upstream part 27 is set to "mt" Variation [per time amount of the above-mentioned mass M] d (M)/dt can be expressed like a degree type (5) based on the conservation of mass.

[0035]

[Equation 3]

$$\frac{d}{dt} M = m_t - m_c \quad \cdots (5)$$

On the other hand, the heat energy in which this inhalation air has them when "Tm", its isochore specific heat, and the isotonic specific heat are set to "Cv" and "Cp", respectively serves as "Cv-M-Tm" in the temperature (henceforth a "downstream intake-air temperature") of the inhalation air which exists in the downstream part 28. Moreover, since the heat energy which the inhalation air which flows into a combustion chamber 29 from "Cp-mt-Tha" and the downstream part 28 has [the heat energy which the inhalation air which flows into the downstream part 28 from the upstream part 27 has] is "Cp-mc-Tm", the variation d (Cv-M-Tm)/dt per time amount of above-mentioned heat energy Cv-M-Tm can be expressed like a degree type (6) based on a heat energy conservation law.
[0036]
[Equation 4]

$$\frac{d}{dt}(C_v \cdot M \cdot T_m) = C_p \cdot m_t \cdot T_{ha} - C_p \cdot m_c \cdot T_m \quad \cdots (6)$$

Moreover, the equation of state about the inhalation air which exists in the downstream part 28 will become like the following equation (7), if the pressure (henceforth a "downstream intake pressure") of the inhalation air for "V" and the said division 28 is set to "Pm" and it sets a gas constant to "R" for the volume of the downstream part 28.
[0037]
[Equation 5]

$$P_m \cdot V = M \cdot R \cdot T_m \quad \cdots (7)$$

Here, if the ratio of specific beat of air is set with "kappa" (=Cp/Cv), a formula (5) can express the following formulas (9) and a formula (6) like the following formulas (8) using the above-mentioned formula (7).
[0038]
[Equation 6]

$$\frac{d}{dt} P_m = \kappa \cdot \frac{R}{V} \cdot (m_t \cdot T_{ha} - m_c \cdot T_m) \quad \cdots (8)$$

$$\frac{d}{dt}\left(\frac{P_m}{T_m}\right) = \frac{R}{V} \cdot (m_t - m_c) \quad \cdots (9)$$

Furthermore, if discrete spacing is set to "deltat", the left part of each [these] type (8) and (9) can be expressed as shown in a degree type (10) and (11).
[0039]
[Equation 7]

$$\frac{d}{dt} P_m = \frac{P_m(i) - P_m(i-1)}{\Delta t} \quad \cdots (10)$$

$$\frac{d}{dt}\left(\frac{P_m}{T_m}\right) = \frac{\frac{P_m}{T_m}(i) - \frac{P_m}{T_m}(i-1)}{\Delta t} \quad \cdots (11)$$

Therefore, the following discrete formulas (12) and (13) are drawn from each [these] type (8) - (11). In addition, in this formula (12) and (13), "i" in a parenthesis shows a value and "i-1" shows a value last time this time, respectively.
[0040]
[Equation 8]

$$P_m(i) = P_m(i-1) + \Delta t \cdot \kappa \cdot \frac{R}{V} \cdot (m_t(i-1) \cdot T_{ha} - m_c(i-1) \cdot T_m(i-1)) \cdots (12)$$

$$\frac{P_m}{T_m}(i) = \frac{P_m}{T_m}(i-1) + \Delta t \cdot \frac{R}{V} \cdot (m_t(i-1) - m_c(i-1)) \quad \cdots (13)$$

On the other hand, the inhalation air content mc in a cylinder can be calculated using the following empirical formula (14).
[0041]
[Equation 9]

$$m_c = \frac{T_0}{T_m} \cdot (a \cdot P_m - b) \quad \cdots (14)$$

In an upper type (14), each of "a" and "b" is constants, and is set as the flow of the inhalation air in the part from the downstream part 28 to a combustion chamber 29 at the affecting engine control parameter, i.e., here, based on the engine engine speed NE and valve timing VT. The relation between these constants a or a constant b and the engine engine speed NE, and valve timing VT is beforehand defined by experiment, and is memorized by the memory 32 of an arithmetic unit 30 as a function map. Moreover, "To" is the reference temperature (constant) of the inhalation air when setting up each constants a and b by such experiment.
[0042] As shown in each following formula (15) and (16), if this empirical formula (14) is used, each above-mentioned formula (12) and (13) can deform.
[0043]
[Equation 10]

$$P_m(i) = P_m(i-1) + \Delta t \cdot \kappa \cdot \frac{R}{V} \cdot \left(m_t(i-1) \cdot T_{ha} - T_0 \cdot \left(a \cdot P_m(i-1) - b\right)\right) \quad \cdots (15)$$

$$\frac{P_m}{T_m}(i) = \frac{P_m}{T_m}(i-1) + \Delta t \cdot \frac{R}{V} \cdot \left(m_t(i-1) - \frac{T_0}{T_m(i-1)} \cdot \left(a \cdot P_m(i-1) - b\right)\right) \quad \cdots (16)$$

Moreover, it can ask for the downstream intake-air temperature Tm using the formula (17) of the following obtained from each [these] type (15) and (16).
[0044]
[Equation 11]

$$T_m(i) = \frac{P_m(i)}{\frac{P_m}{T_m}(i)} \quad \cdots (17)$$

Each [these] type (15) So that clearly from - (17) Throttle-valve through put mt in this time, It is based on the downstream intake pressure Pm, the downstream intake-air temperature Tm, and the upstream intake-air temperature Tha. The downstream intake pressure Pm and the downstream intake-air temperature Tm after the above-mentioned discrete spacing deltat can be presumed after a predetermined period (i.e., here) from this time. Furthermore, by substituting for a formula (14) the downstream intake pressure Pm presumed in this way and the downstream intake-air temperature Tm, the inhalation air content mc in a cylinder after discrete spacing deltat can be presumed from this time.
[0045] Moreover, he is trying to calculate the above-mentioned throttle-valve through put mt in prediction processing of this operation gestalt according to two approaches the followings differ. Hereafter, the approach at the time of calculating this throttle-valve through put mt is explained.
[0046] First, the procedure at the time of calculating the throttle-valve through put mt based on the detecting signal of an air flow meter 41 is explained. As everyone knows, an air flow meter 41 detects tales doses using the heating value taken from this heat ray 412 changing according to an inhalation air content, in case inhalation air passes through the perimeter of a heat ray 412. The relation between the detecting signal of this air flow meter 41 and an inhalation air content is beforehand called for by experiment, and is memorized by the memory 32 of an arithmetic unit 30 as a function map. Therefore, an inhalation air content can be calculated based on the detecting signal and this function map of an air flow meter 41.
[0047] However, as compared with a heat ray 412, generally, since heat capacity is large, the above-mentioned glass layer 414 has the inclination for the temperature Tgs to be overdue to change of the amount of the inhalation air which passes near the detecting element 410, and to change. For this reason, if there is an inhalation air content calculated from the above-mentioned function map if it is at the time of steady operation from which an inhalation air content does not change at the time of transient operation from which a true inhalation air content and this inhalation air content of a match change, the inhalation air content calculated from a function map comes to shift from a true inhalation air content.
[0048] Then, in order to foresee beforehand the response delay about the temperature change of such a glass layer 414 and to calculate a true inhalation air content, he builds the thermal equilibrium model about this layer 414, and is trying to compute an inhalation air content with this operation gestalt based on the reverse model. In addition, in the following explanation, a true inhalation air content is made into the throttle-valve through put mt, and the inhalation air content acquired based on the detecting signal and the above-mentioned function map of an air flow meter 41 is distinguished as a map operation value GA.
[0049] First, if temperature of a heat ray 412 is set to "Tht" (refer to drawing 2), the variation d (Tgs)/dt of the temperature Tgs of the glass layer 414 can be expressed like the following formulas (18) from the balance with the heating value transmitted to the glass layer 414 from a heat ray 412, and the heating value transmitted to inhalation air from this layer 414.

[0050]
[Equation 12]

$$A \cdot \frac{d}{dt} T_{gs} = B \cdot \left(T_{ht} - T_{gs}\right) - \left(C + D \cdot \sqrt{m_t}\right) \cdot \left(T_{ht} - T_{ha}\right) \quad \cdots (18)$$

Here, "A", "B", "C", and "D" are constants determined according to **, such as the cross section of a heat ray 412, die length and its resistivity, and a heat transfer rate between the glass layer 414 and a heat ray 412, a heat transfer rate between the glass layer 414 and inhalation air.
[0051] Moreover, at the time of steady operation, since transfer of the heat between the glass layer 414, and a heat ray 412 and inhalation air is lost, as shown in a degree type (19) and (20), the left part d (Tgs)/dt of a formula (18), i.e., the temperature variation of the glass layer 414, is set to "0", and the map operation value GA and the throttle-valve through put mt become equal.
[0052]
[Equation 13]

$$0 = B \cdot \left(T_{ht} - T_{gs}\right) - \left(C + D \cdot \sqrt{m_t}\right) \cdot \left(T_{ht} - T_{ha}\right) \quad \cdots (19)$$

$$GA = m_t \quad \cdots (20)$$

Therefore, the following formula (21) is obtained from each above-mentioned formula (19) and (20).
[0053]
[Equation 14]

$$GA = \left(\frac{B}{D}\right)^2 \cdot \left\{\frac{T_{ht} - T_{gs}}{T_{gs} - T_{ha}} - \frac{C}{B}\right\}^2 \quad \cdots (21)$$

Furthermore, if a formula (18) is transformed using this formula (21), the degree type (22) from which the temperature Tgs of the glass layer 414 was eliminated will be obtained.
[0054]
[Equation 15]

$$\frac{d\sqrt{GA}}{dt} = \left(\frac{B+C}{A} + \frac{D}{A} \cdot \sqrt{GA}\right) \cdot \left(\sqrt{m_t} - \sqrt{GA}\right) \quad \cdots (22)$$

Moreover, the left part of this formula (22) can be expressed like a degree type (23), if discrete spacing is set to "deltat."
[0055]
[Equation 16]

$$\frac{d\sqrt{GA}}{dt} = \frac{\sqrt{GA(j)} - \sqrt{GA(j-1)}}{\Delta t} \quad \cdots (23)$$

Therefore, the following discrete formulas (24) are drawn from each above-mentioned formula (22) and (23). In addition, in this formula (24), "alpha" and "beta" are constants which become settled by above-mentioned constant A-D, and "j" in a parenthesis shows a value and "j-1" shows the value last time this time, respectively.
[0056]
[Equation 17]

$$m_t(j) = \left\{\sqrt{GA(j)} + \frac{\alpha}{\Delta t} \cdot \frac{\sqrt{GA(j)} - \sqrt{GA(j-1)}}{\beta + \sqrt{GA(j)}}\right\}^2 \quad \cdots (24)$$

The throttle-valve through put mt in this time (j) can be presumed based on the map operation value GA in this time (j), and the map operation value GA (j-1) in front of discrete spacing deltat so that clearly from this formula (24).
[0057] Next, the procedure at the time of calculating the throttle-valve through put mt based on engine operational status, such as the throttle opening TA, is explained. When the opening part of a throttle valve 24 is assumed to be a kind of orifice, the amount (throttle-valve through put mt) of the fluid which passes this orifice is expressed by each following formula (25) and (26) as everyone knows.
[0058]
[Equation 18]

$$m_t = \mu \cdot A_t \cdot \frac{P_a}{\sqrt{R \cdot T_{ha}}} \cdot \Phi(P_m, P_a) \quad \cdots (25)$$

$$\Phi(P_m, P_a) = \begin{cases} \sqrt{\left(\frac{2\kappa}{\kappa+1}\right) \cdot \left(\frac{2}{\kappa+1}\right)^{\frac{1}{\kappa-1}}} & \frac{P_m}{P_a} \le \left(\frac{2}{\kappa+1}\right)^{\frac{\kappa}{\kappa-1}} \\ \sqrt{\frac{2\kappa}{\kappa-1}\left\{\left(\frac{P_m}{P_a}\right)^{\frac{2}{\kappa}} - \left(\frac{P_m}{P_a}\right)^{\frac{\kappa+1}{\kappa}}\right\}} & \frac{P_m}{P_a} > \left(\frac{2}{\kappa+1}\right)^{\frac{\kappa}{\kappa-1}} \end{cases} \quad \cdots (26)$$

Here, "mu" is the flow coefficient of an orifice (opening part of a throttle valve 24), and "Pa" is atmospheric pressure (constant value). Moreover, "At" is the opening area of a throttle valve 24, and can ask for this uniquely from the throttle opening TA.

[0059] Here, if the time of steady operation by which the throttle opening TA is held uniformly is assumed, a formula (25) will become like a degree type (27).

[0060]

[Equation 19]

$$m_{tTA} = \mu \cdot A_t \cdot \frac{P_a}{\sqrt{R \cdot T_{ha}}} \cdot \Phi(P_{mTA}, P_a) \quad \cdots (27)$$

Here, "mtTA" and "PmTA" show the throttle-valve through put mt at the time of steady operation, and the downstream intake pressure Pm, respectively. The throttle-valve through put mtTA at the time of these steady operations and the downstream intake pressure PmTA can be determined as the flow of the inhalation air in the part from the upstream part 27 to a combustion chamber 29 at the affecting engine control parameter, i.e., here, based on the throttle opening TA, the engine engine speed NE, and valve timing VT. The relation between the throttle-valve through put mtTA at the time of these steady operations or the downstream intake pressure PmTA, the throttle opening TA and the engine engine speed NE, and valve timing VT is beforehand called for by experiment, and is memorized by the memory 32 of an arithmetic unit 30 as a function map.

[0061] If this formula (27) is used, a formula (25) can be expressed like a degree type (28).

[0062]

[Equation 20]

$$m_t = m_{tTA} \cdot \frac{\Phi(P_m, P_a)}{\Phi(P_{mTA}, P_a)} \quad \cdots (28)$$

Furthermore, if it is at the time of steady operation, since the throttle-valve through put mtTA and the inhalation air content mc in a cylinder become equal (mtTA=mc) and the downstream intake-air temperature Tm and the upstream intake-air temperature Tha become equal (Tm=Tha), the above-mentioned formula (14) can be expressed like a degree type (29).

[0063]

[Equation 21]

$$m_{tTA} = \frac{T_0}{T_{ha}} \cdot (a \cdot P_{mTA} - b) \quad \cdots (29)$$

And if this formula (29) is used, the above-mentioned formula (28) can be expressed still like a degree type (30).

[0064]

[Equation 22]

$$m_t = \frac{T_0}{T_{ha}} \cdot (a \cdot P_{mTA} - b) \cdot \frac{\Phi(P_m, P_a)}{\Phi(P_{mTA}, P_a)} \quad \cdots (30)$$

The throttle-valve through put mt can be presumed based on the value PmTA of the downstream intake pressure Pm when assuming that it is at the steady operation time (TA, NE, VT) in the upstream intake-air temperature Tha and the downstream intake pressure Pm, the atmospheric pressure Pa, and list in this time so that clearly from this formula (30).

[0065] He is trying to predict the inhalation air content mc in a cylinder after a predetermined period to be the throttle-valve through put mt calculated based on each option in this way from this time with this operation gestalt based on each formula (14) - (17) mentioned above. In addition, in the following explanation, the throttle-valve through put mt asked for the throttle-valve through put mt calculated based on engine operational status, such as the throttle opening TA, based on the detecting signal of the 1 air flow meter throttle-valve through put estimate mt 41 is distinguished as throttle-valve through put measured value mt2.
[0066] Next, drawing 3 and drawing 4 are combined, referred to and explained about the detail of the prediction processing by the equipment of this operation gestalt. Drawing 3 R> 3 and drawing 4 are flow charts which show an example of the procedure at the time of predicting the inhalation air content mc in a cylinder. this processing of a series of is performed by the arithmetic unit 30 the interrupt period (for example, -- "-- every 8msec.") for every predetermined time.
[0067] On the occasion of this processing, the prediction period tfwd at the time of predicting an inhalation air content is set up first (step 100). This prediction period tfwd will be the fuel oil consumption in the last fuel injection, and a thing set up according to fuel injection duration, if it puts in another way. Therefore, the inhalation air content mc in a cylinder after the time amount which the last fuel injection took from this time passes will be predicted here. Incidentally, this fuel injection duration is computed through processing concerning fuel injection with this another processing. Moreover, in processing concerning this fuel injection, fuel oil consumption is computed based on the newest inhalation air content mc in a cylinder computed through this processing.
[0068] next, the downstream intake pressure Pm after [this time to] the prediction period tfwd, the downstream intake-air temperatures Tm, and those ratios -- Pm/Tm is computed based on said throttle-valve through put estimate mt1 (step 200). In addition, the downstream intake pressure Pm after the prediction period tfwd computed below based on the throttle-valve through put estimate mt1 the downstream intake-air temperatures Tm and those ratios -- Pm/Tm with "Pm1tfwd", "Tm1tfwd", and "Pm1 tfwd/Tm1tfwd", respectively moreover, the downstream intake pressure Pm in the middle of the calculation, the downstream intake-air temperatures Tm, and those ratios -- it writes "Pm1 (i)", "Tm1 (i)", and "Pm1/Tm1 (i)", respectively. [Pm/Tm]
[0069] On the occasion of calculation of this downstream intake-pressure Pm1tfwd and downstream intake-air temperature Tm1tfwd, processing only whose count of predetermined repeats the operation based on each above-mentioned formula (15) - (17) and a formula (30) is performed.
[0070] That is, as shown in drawing 4 , the increment of the counter value i showing the count of a loop of this processing (initial value : "0") is carried out first (step 202), and it is judged whether next the prediction periods tfwd are deltat1 or more predetermined time (step 204). Here, the above-mentioned predetermined time deltat1 is set up equally (for example, "8msec.") to the interrupt period of this routine. And when the prediction period tfwd is judged to be these deltat1 or more predetermined time (step 204: YES), discrete spacing deltat of each above-mentioned formula (15) and (16) is set up equally to predetermined time deltat1 (step 206).
[0071] next, based on a formula (30), the throttle-valve through put estimate mt1 (i) computes -- having -- further -- after that and each formula (15) - (17) -- being based -- the downstream intake pressure Pm 1 (i), the downstream intake-air temperatures Tm1 (i), and those ratios -- Pm1 (i)/Tm1 (i) is computed, respectively (step 208). And predetermined time deltat1 is subtracted from the current prediction period tfwd, and the subtraction value (tfwd-delta t1) is set up as a new prediction period tfwd (step 210).
[0072] Next, when it is judged whether this new prediction period tfwd is below "0" (step 212) and this prediction period tfwd is judged to be longer than "0" (step 212: NO), processing after step 202 is performed again. Under the present circumstances, if it is judged that the prediction period tfwd is less than deltat1 predetermined time in step 204 (step 204: NO), discrete spacing deltat will be set up equally to the prediction period tfwd (step 207), and processing after step 208 will be performed.
[0073] And by repeating processing of steps 202-212 If the prediction period tfwd becomes below "0" (step 212: YES) the downstream intake pressure Pm 1 (i), the downstream intake-air temperature Tm1 (i), and a ratio -- Pm1/Tm1 (i) of them downstream intake-pressure Pm1tfwd after the prediction period tfwd, downstream intake-air temperature Tm1tfwd, and a ratio -- it is set up as Pm1 tfwd/Tm1tfwd, respectively (step 214).
[0074] For example, when the interrupt period of this routine is "8msec." and the prediction period tfwd is set as "30msec." through processing of previous step 100, Discrete spacing deltat will be set up in order through processing of the above-mentioned step 204,206,207 in the mode "8msec." ->"8msec." ->"8msec." -

> "6msec.", and processing to step 202 - step 212 will be repeated "4 times." and the downstream intake pressure Pm 1 (4) in case the counter value i is "4", the downstream intake-air temperatures Tm1 (4), and those ratios Pm1/Tm1 (4) -- downstream intake-pressure Pm1tfwd after [this time to] the prediction period tfwd, downstream intake-air temperature Tm1tfwd, and a ratio -- it will be set up as Pm1 tfwd/Tm1tfwd, respectively.

[0075] Then, while the counter value i was reset by "0", after discrete spacing deltat is set up equally to the above-mentioned predetermined time deltat1 (step 216), processing is returned to step 300 shown in drawing 3 .

[0076] At step 300, the map operation value GA in this time (j) and (it is hereafter written as "GA(0)") are computed based on the detecting signal of an air flow meter 41. Next, based on the map operation value GA in this this time (0), and the map operation value GA (j-1) (it is hereafter written as "GA (-1)") computed in the last interrupt timing, the throttle-valve through put measured value mt2 in this time (0) is computed using a previous formula (24) (step 400).

[0077] and this throttle-valve through put measured value mt2 (0) -- being based -- each previous formula (15) - (17) -- using -- the downstream intake pressure Pm after discrete spacing deltat (i), the downstream intake-air temperatures Tm (i), and those ratios -- Pm/Tm (i) is computed, respectively (step 500). In addition, the downstream intake pressure Pm computed in this step 500 (i) the downstream intake-air temperatures Tm (i) and those ratios -- the value computed to this interrupt timing among Pm/Tm (i) with "Pm2 (1)", "Tm2 (1)", and "Pm2/Tm2 (1)", respectively It writes "Pm2 (0)", "Tm2 (0)", and "Pm2/Tm2 (0)", respectively. [the value computed to the last interrupt timing]

[0078] each following formula (31), (32), and (33) -- being based -- the downstream intake pressure Pmtfwd after [this time to] the prediction period tfwd, the downstream intake-air temperatures Tmtfwd, and those ratios -- while Pmtfwd/Tmtfwd is computed, the inhalation air content mctfwd in a cylinder after the prediction period tfwd is computed by being based on the formula (34) obtained from the above-mentioned formula (14) (step 600). [next,]

[0079]

[Equation 23]

$$P_{mtfwd} = P_{m1tfwd} - P_{m1}(0) + P_{m2}(0) \quad \cdots(31)$$

$$\frac{P_{mtfwd}}{T_{mtfwd}} = \frac{P_{m1tfwd}}{T_{m1tfwd}} - \frac{P_{m1}}{T_{m1}}(0) + \frac{P_{m2}}{T_{m2}}(0) \quad \cdots(32)$$

$$T_{mtfwd} = \frac{P_{mtfwd}}{\dfrac{P_{mtfwd}}{T_{mtfwd}}} \quad \cdots(33)$$

$$m_{ctfwd} = \frac{\dfrac{P_{mtfwd}}{T_{mtfwd}}}{P_{mtfwd}} \cdot T_o\left(a \cdot P_{mtfwd} - b\right) \quad \cdots(34)$$

In this way, after the inhalation air content mctfwd in a cylinder is computed, the initial value of data processing in next interrupt timing is set up, respectively (step 700).

[0080] Drawing 5 is a timing chart which shows the setting mode of such initial value. In this drawing, while engine operation is started in time of day t1, this routine shall be started.

[0081] Initial value [in / as shown in this drawing / the interrupt timing (time of day t2 and t3) of the 2nd henceforth], Namely, the downstream intake pressures [Pm / Pm (0) and / 2] 1 (0), the downstream intake-air temperature Tm1 (0), In Tm(s)2 (0), these ratios Pm1/Tm1 (0), Pm2/Tm2 (0), and a list, the map operation value GA (-1) It is set up as follows using the value computed in the last interrupt timing as the values (Pm1 (1) etc.) or the value (GA (0)) in this time after discrete spacing deltat, respectively.

[0082]

[Equation 24]

$$P_{m1}(0) \leftarrow P_{m1}(1)$$
$$P_{m2}(0) \leftarrow P_{m2}(1)$$
$$T_{m1}(0) \leftarrow T_{m1}(1)$$
$$T_{m2}(0) \leftarrow T_{m2}(1)$$
$$\frac{P_{m1}}{T_{m1}}(0) \leftarrow \frac{P_{m1}}{T_{m1}}(1)$$
$$\frac{P_{m2}}{T_{m2}}(0) \leftarrow \frac{P_{m2}}{T_{m2}}(1)$$
$$GA(-1) \leftarrow GA(0)$$

On the other hand, about the initial value in the first interrupt timing (time of day t1), it is set up as follows from the calculation value in the last interrupt timing not existing.
[0083]
[Equation 25]
$$P_{m1}(0) \leftarrow P_a$$
$$P_{m2}(0) \leftarrow P_a$$
$$T_{m1}(0) \leftarrow T_{ha}$$
$$T_{m2}(0) \leftarrow T_{ha}$$
$$\frac{P_{m1}}{T_{m1}}(0) \leftarrow \frac{P_a}{T_{ha}}$$
$$\frac{P_{m2}}{T_{m2}}(0) \leftarrow \frac{P_a}{T_{ha}}$$
$$GA(-1) \leftarrow 0$$

Thus, after setting up each initial value in next interrupt timing, processing of this routine is once ended.
[0084] As explained above, with this operation gestalt, a fluid model is built based on the conservation of mass in the heat energy conservation law list about the inhalation air of the downstream part 28. The fluid model, Based on the downstream intake pressure Pm and the downstream intake-air temperature Tm, the downstream intake pressure Pmtfwd after the prediction period tfwd and the downstream intake-air temperature Tmtfwd are presumed from this time in the throttle-valve through put mt and the upstream intake-air temperature Tha, and a list. Furthermore, he is trying to predict the inhalation air content mctfwd in a cylinder after the prediction period tfwd from this time based on them.
[0085] (1) Therefore, even if it is the case where the downstream intake-air temperature Tm changes from this time transitionally, when the transitional change has been grasped, the inhalation air content mc in a cylinder can be predicted, and a very accurate prediction result can be obtained.
[0086] In case the fluid model of such inhalation air is built, the conservation of mass and the heat energy conservation law about inhalation air of the downstream part 28 (2) Moreover, a previous formula (12), He is trying to presume the downstream intake pressure Pmtfwd after the prediction period tfwd, and the downstream intake-air temperature Tmtfwd from this time by a discrete formula's as shown in (13) expressing, and performing processing which repeats the operation based on these dispersion type (12) and (13) the number of predetermined times. Therefore, the downstream intake pressure Pmtfwd required for prediction of the inhalation air content mctfwd in these cylinders and the downstream intake-air temperature Tmtfwd can be presumed now based on a comparatively easy algorithm.
[0087] (3) In case the above-mentioned repetitive operation is performed a predetermined interrupt period, he is trying to compute the downstream intake pressure Pm (0) and the downstream intake-air temperature Tm (0) in this time used to next interrupt timing in this interrupt timing furthermore. For this reason, not using the sensor for detecting the pressure and temperature in the downstream part 28 etc., ** can also ask for these downstream intake pressure Pm (0) and the downstream intake-air temperature Tm (0) serially through the above-mentioned repetitive operation, and can attain now simplification of the configuration of inhalation air content prediction equipment.
[0088] (4) By presuming the downstream intake-air temperature Tm in this time (0) especially, the need of generally using the low general-purpose temperature sensor of responsibility is lost, and the fall of the predictability resulting from the detection error of such a sensor can be avoided now.
[0089] Moreover, he is trying to calculate the throttle-valve through put estimate mt1 presumed from engine operational status, such as the throttle opening TA, and the throttle-valve through put measured value mt2 computed based on the detecting signal of an air flow meter 41 as throttle-valve through put mt with this

operation gestalt, respectively.
[0090] Here, when the downstream intake pressures [Pm / Pm (i), Pm /2 / (0), and / 2] 1 (1) called for using these throttle-valves through put estimate mt1 and the throttle-valve through put measured value mt2 and the downstream intake-air temperature Tm1 (i), Tm2 (0), and Tm2 (1) compare with an actual intake pressure and an actual intake-air temperature, it is checked by experiment of this invention persons that there are the following inclinations.
[0091] That is, about the downstream intake pressure Pm 1 (i) called for using the throttle-valve through put estimate mt1, the downstream intake-air temperatures Tm1 (i), and those ratios Pm1/Tm1 (i), there is an inclination for the temporal response to reflect correctly the actual temporal response of an intake pressure or an intake-air temperature especially. On the other hand, about the downstream intake pressures [Pm / Pm (0) and / 2] 2 (1) called for using the throttle-valve through put measured value mt2, the downstream intake-air temperature Tm2 (0), Tm(s)2 (1) and those ratios Pm2/Tm2 (0), and Pm2/Tm2 (1), there is an inclination for it to be well in agreement with an intake pressure, an intake-air temperature, or the actual value of those ratios at the time of steady operation.
[0092] For this reason, if it is at the time of transient operation by computing the downstream intake pressure Pmtfwd after the final prediction period tfwd, and the downstream intake-air temperature Tmtfwd using each previous formula (31) - (33), while being able to make the temporal response of an actual intake pressure and an intake-air temperature reflect in that calculation correctly, it is at the time of steady operation, [0093]. [i.e.,]
[Equation 26]

$$P_{mt1fwd} = P_{m1}(0)$$

$$\frac{P_{mt1fwd}}{T_{mt1fwd}} = \frac{P_{m1}}{T_{m1}}(0)$$

It is [0094] when ******(ing).
[Equation 27]

$$P_{mtfwd} = P_{m2}(0)$$

$$\frac{P_{mtfwd}}{T_{mtfwd}} = \frac{P_{m2}}{T_{m2}}(0)$$

Since it becomes, the downstream intake pressure Pmtfwd and the downstream intake-air temperature Tmtfwd come to be called for only based on the throttle-valve through put measured value mt2.
[0095] (5) therefore -- according to this operation gestalt -- the time of steady operation -- be -- the time of transient operation -- be -- the downstream intake pressure Pmtfwd after the prediction period tfwd and the downstream intake-air temperature Tmtfwd can be correctly presumed from this time, as a result the inhalation air content mctfwd in a cylinder can be more correctly predicted now.
[0096] (6) Furthermore, with this operation gestalt, since the thermal equilibrium model about the glass layer 414 of an air flow meter 41 is built and he is trying to calculate the above-mentioned throttle-valve through put measured value mt2 based on the reverse model, the response delay about the temperature change of this layer 414 can be foreseen beforehand, and it can ask for this. Therefore, the more exact throttle-valve through put measured value mt2 can be calculated, and the downstream intake pressure Pmtfwd and the downstream intake-air temperature Tmtfwd can be presumed now still more correctly based on this.
[0097] The 2nd operation gestalt of this invention is explained focusing on difference with the 1st operation gestalt below [the 2nd operation gestalt].
[0098] With this operation gestalt, the point he is trying to apply the inhalation air content prediction equipment concerning this invention to the internal combustion engine which has an intake-pressure sensor as a sensor which detects an inhalation air content is different from the 1st operation gestalt. As shown in drawing 6 , this intake-pressure sensor 46 is attached in the surge tank 22, and detects the pressure Pm of the inhalation air of that interior, i.e., a downstream intake pressure.
[0099] Next, the detail of the prediction processing by the equipment of this operation gestalt is explained. Drawing 7 is a flow chart which shows an example of the procedure at the time of predicting the inhalation air content mc in a cylinder. this processing of a series of is performed by the arithmetic unit 30 the interrupt period (for example, -- "-- every 8msec.") for every predetermined time. In addition, at step 100 shown in this drawing 7 , and step 200, since the same processing as step 100 and steps 200-216 which are shown in

previous drawing 3 and previous drawing 4 is performed, explanation of the contents of processing is omitted.
[0100] After each processing of these steps 100,200 is performed, at step 350, the downstream intake pressure Pm in this time (i) and (it is hereafter written as "Pm3(0)") are computed based on the detecting signal of the intake-pressure sensor 46. Next, the downstream intake pressure Pm detected in the downstream intake pressure Pm 3 (0) detected in this interrupt timing, and the last interrupt timing (i-1) (it is hereafter written as "Pm3 (-1)") Based on the degree type (35) obtained from a previous formula (15), the throttle-valve through put (to namely, the last interrupt timing) mt (i-1) (henceforth "the throttle-valve through put measured value mt3 (-1)") in front of discrete spacing deltat is computed from this time (step 450).
[0101]
[Equation 28]

$$m_{t3}(-1) = \frac{1}{T_{ha}}\left\{\frac{P_{m3}(0) - P_{m3}(-1)}{\Delta t}\cdot\frac{V}{\kappa\cdot R} + T_o\left(a\cdot P_m(0) - b\right)\right\} \quad \cdots(35)$$

Further And this throttle-valve through put measured value mt3 (-1) and a previous formula (16), It is based on the following formula (36) obtained from (17), and (37). The downstream intake-air temperature Tm in this time (0) The ratios Pm3/Tm3 (0) of the downstream intake pressure Pm 3 (0) and the downstream intake-air temperature Tm3 (0) are computed by the list ("Tm3(0) [list]" is written hereafter), respectively (step 550).
[0102]
[Equation 29]

$$\frac{P_{m3}}{T_{m3}}(0) = \frac{P_{m3}}{T_{m3}}(-1) + \Delta t\cdot\frac{R}{V}\cdot\left(m_{t3}(-1) - \frac{T_0}{T_{m3}(-1)}\cdot\left(a\cdot P_{m3}(-1) - b\right)\right) \quad \cdots(36)$$

$$T_{m3}(0) = \frac{P_{m3}(0)}{\frac{P_{m3}}{T_{m3}}(0)} \quad \cdots(37)$$

In addition, in the above-mentioned step 450 and step 550, when computing the downstream intake-air temperature Tm3 (0) etc. based on a formula (35) and (36), the value which the value into which the upstream intake-air temperature Tha was read to the last interrupt timing was used, and was set up based on the last engine engine speed NE and the valve timing VT in interrupt timing about each constants a and b is used. Moreover, when this time is the first interrupt timing, the value in this time [intake-air temperature / Tha / upstream] and the value to which each constants a and b are set based on the engine engine speed NE (= "0") and valve timing VT at the time of an engine halt are used.
[0103] Next, the formula which permuted "Pm2 (0)" and "Pm2/Tm2 (0)" by "Pm3 (0)" and "Pm3/Tm3 (0)" in each previous type (31) and (32), respectively, each formula (33) and (34) -- using -- the downstream intake pressure Pmtfwd after [this time to] the prediction period tfwd, the downstream intake-air temperatures Tmtfwd, and those ratios, while Pmtfwd/Tmtfwd is computed The inhalation air content mctfwd in a cylinder after the prediction period tfwd is computed (step 650).
[0104] In this way, after the inhalation air content mctfwd in a cylinder is computed, the initial value of data processing in next interrupt timing is set up, respectively (step 750). Drawing 8 is a timing chart which shows the setting mode of such initial value. In this drawing, while engine operation is started in time of day t1, this routine shall be started.
[0105] Initial value [in / as shown in this drawing / the interrupt timing (time of day t2 and t3) of the 2nd henceforth], In the downstream intake pressures [Pm / Pm (0) and / 3 (-1)] 1, the downstream intake-air temperature Tm1 (0), Tm3 (-1), and a list, namely, these ratios Pm1/Tm1 (0) and Pm3/Tm3 (-1) It is set up as follows using the values (Pm3 (0), Tm3 (0), etc.) calculated in the last interrupt timing as the values (Pm1 (1) etc.) or the value in this time after discrete spacing deltat, respectively.
[0106]
[Equation 30]

$P_{m1}(0) \leftarrow P_{m1}(1)$
$P_{m3}(-1) \leftarrow P_{m3}(0)$
$T_{m1}(0) \leftarrow T_{m1}(1)$
$T_{m3}(-1) \leftarrow T_{m3}(0)$
$\frac{P_{m1}}{T_{m1}}(0) \leftarrow \frac{P_{m1}}{T_{m1}}(1)$
$\frac{P_{m3}}{T_{m3}}(-1) \leftarrow \frac{P_{m3}}{T_{m3}}(0)$
$P_{m3}(-1) \leftarrow P_{m3}(0)$

On the other hand, about the initial value in the first interrupt timing (time of day t1), it is set up as follows from the last calculation value or last detection value in interrupt timing not existing.
[0107]
[Equation 31]
$P_{m1}(0) \leftarrow P_a$
$P_{m3}(-1) \leftarrow P_a$
$T_{m1}(0) \leftarrow T_{ha}$
$T_{m3}(-1) \leftarrow T_{ha}$
$\frac{P_{m1}}{T_{m1}}(0) \leftarrow \frac{P_a}{T_{ha}}$.
$\frac{P_{m3}}{T_{m3}}(-1) \leftarrow \frac{P_a}{T_{ha}}$
$P_{m3}(-1) \leftarrow P_a$

Thus, after setting up each initial value in next interrupt timing, processing of this routine is once ended.
[0108] Also in the 2nd operation gestalt explained above, the operation effectiveness of an abbreviation EQC can be acquired about (1) indicated in the 1st operation gestalt, (2), and (4). Moreover, about the operation effectiveness of (3) indicated in the 1st operation gestalt, conversely [of that for which the intake-pressure sensor 46 for detecting the downstream intake pressure Pm is needed separately], since an air flow meter 41 does not need the sensor which becomes unnecessary and detects the downstream intake-air temperature Tm at least, at this point, simplification of the configuration of inhalation air content prediction equipment can be attained.
[0109] Furthermore, the downstream intake pressures [Pm / Pm (0) and / 3] 3 (1) called for based on the detecting signal of the intake-pressure sensor 46, the downstream intake-air temperature Tm3 (0), Tm(s)3 (1) and those ratios Pm3/Tm3 (0), and Pm3/Tm3 (1) have the inclination for it to be well in agreement with an intake pressure, an intake-air temperature, or the actual value of those ratios at the time of steady operation. Therefore, the operation effectiveness equivalent to (5) indicated in the 1st operation gestalt also according to this operation gestalt can be done so.
[0110] Each operation gestalt explained above can also change and carry out a configuration as follows.
- With each above-mentioned operation gestalt, as an amount of the inhalation air which passes a throttle valve 24, although the estimate based on engine operational status, such as the throttle opening TA, and the actual measurement based on the detecting signal of an air flow meter 41 or the sensor of intake-pressure sensor 46 grade are calculated, respectively and the inhalation air content mc in a cylinder was predicted using each [these] value, based on either these estimate or an actual measurement, it may be made to perform this prediction.
[0111] - Although it was made to predict the inhalation air content mc in a cylinder with each above-mentioned operation gestalt supposing the internal combustion engine 10 having the device in which the valve timing of an inlet valve 26 is changed, also in the internal combustion engine which does not have this device, the inhalation air content mc in a cylinder can be predicted according to the same procedure.
[0112] - When the device which controls the flow of the inhalation air of the inhalation-of-air path 20, for example, the swirl valve which controls the reinforcement of the swirl generated in a combustion chamber 29, performs the above-mentioned prediction again in the internal combustion engine formed in this inhalation-of-air path 20, set up the above-mentioned constants a and b, the downstream intake pressure PmTA at the time of steady operation, and the throttle-valve through put mtTA as a function of the controlled variables (for example, opening of a swirl valve etc.) of the above-mentioned device.
[0113] - In prediction processing of each above-mentioned operation gestalt, although the empirical formula

(14) which makes this air content mc the function of the downstream intake-air temperature Tm and the downstream intake pressure Pm was used when calculating the inhalation air content mc in a cylinder, the method of calculating this air content mc is not limited to this.
[0114] - Although the downstream intake pressure Pm and the downstream intake-air temperature Tm were computed with each above-mentioned operation gestalt by discretizing each above-mentioned formula (8) obtained as a fluid model of inhalation air, and (9), and performing a loop operation, you may make it compute these downstream intake pressure Pm and the downstream intake-air temperature Tm based on the operation expression which solved each [these] type (8) and (9) analytically.
[0115] - Although the above-mentioned prediction period tfwd was set as the value suitable for calculation of this fuel oil consumption with each above-mentioned operation gestalt that the inhalation air content mc in a cylinder used for calculation of fuel oil consumption should be predicted, this prediction processing is applicable also to other engine control, such as ignition timing control, by setting up the prediction period tfwd suitably.
[0116] - Although the interrupt period of a prediction manipulation routine shown in drawing 3 or drawing 7 and discrete spacing deltat were equally set up with each above-mentioned operation gestalt, this discrete spacing deltat can also be changed "1/2 of range which can determine initial value in next interrupt timing, i.e., interrupt period," twice etc., for example so that it may become 1/n time (n: integer).

[Translation done.]

* NOTICES *

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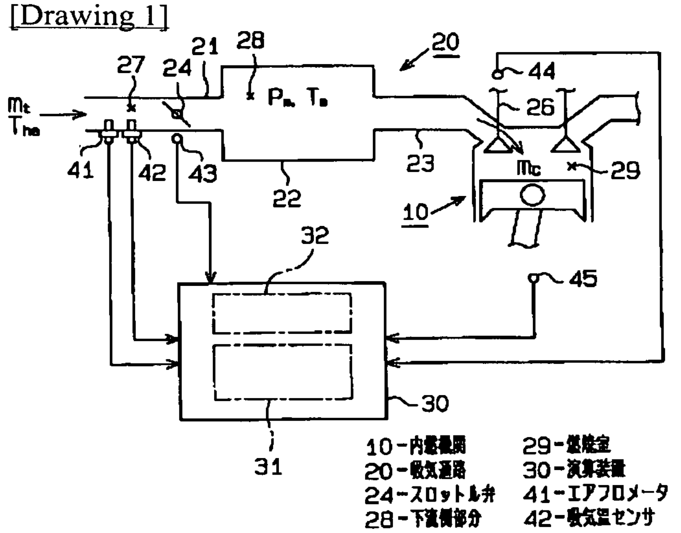
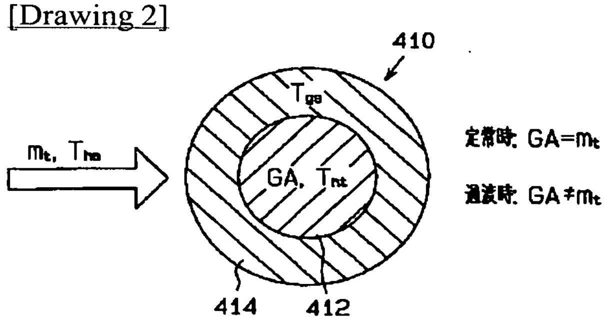
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

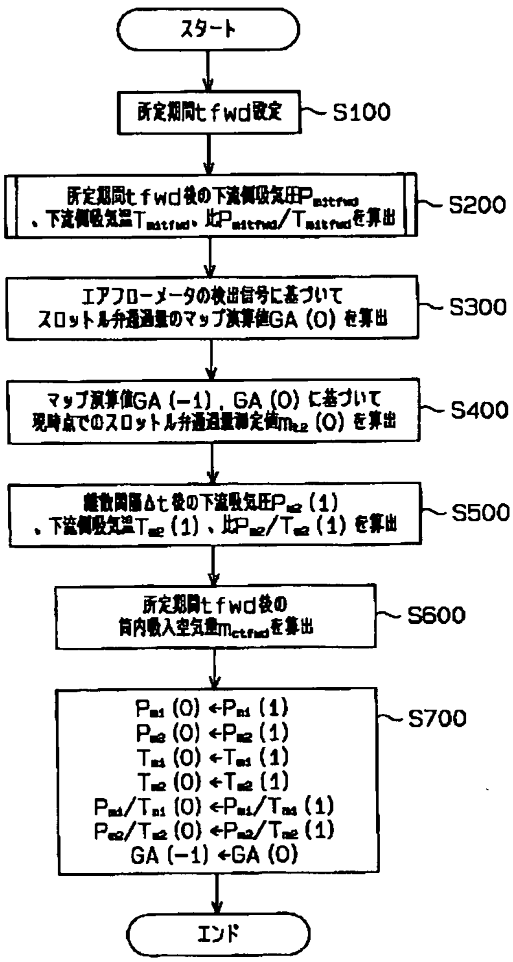
[Drawing 1]



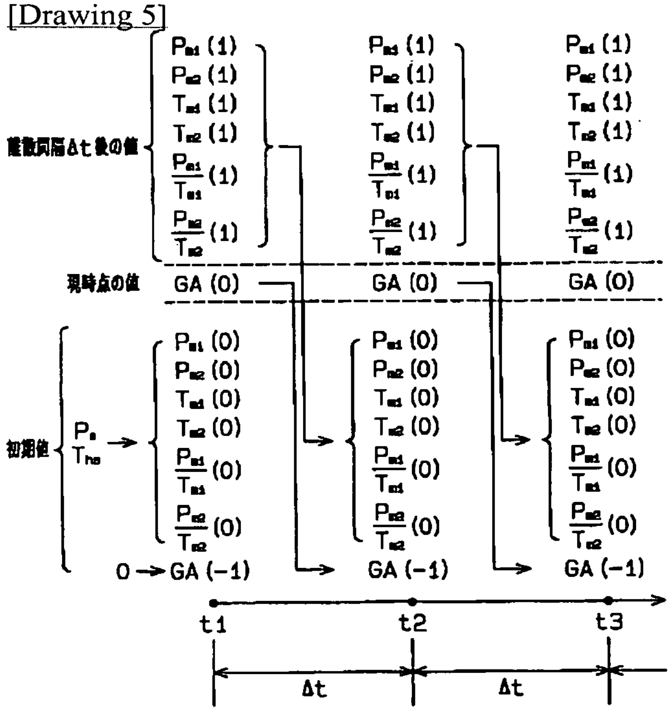
[Drawing 2]



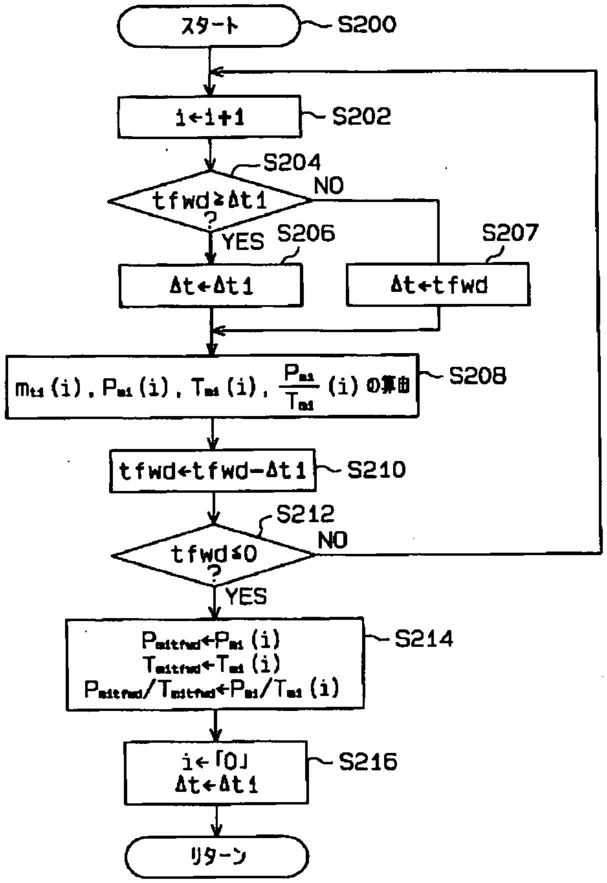
[Drawing 3]



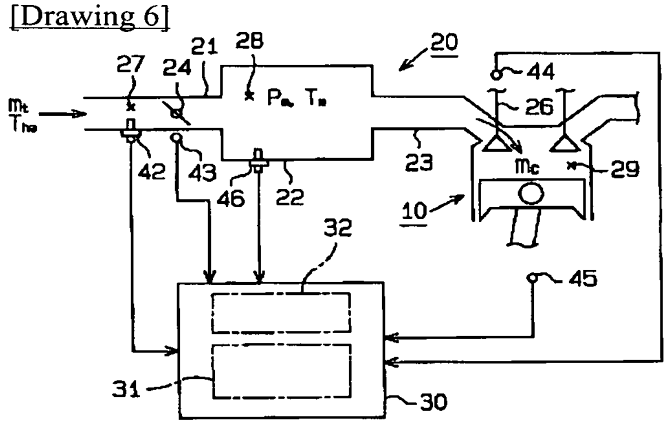
[Drawing 5]



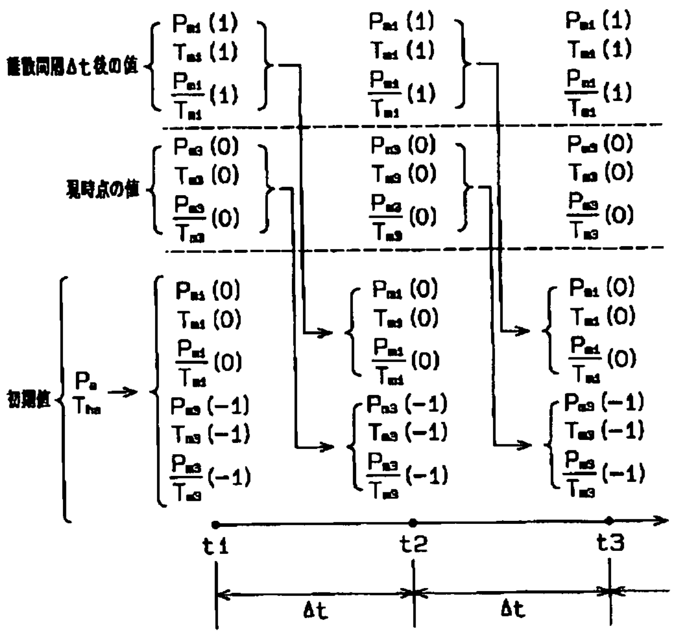
[Drawing 4]



[Drawing 6]

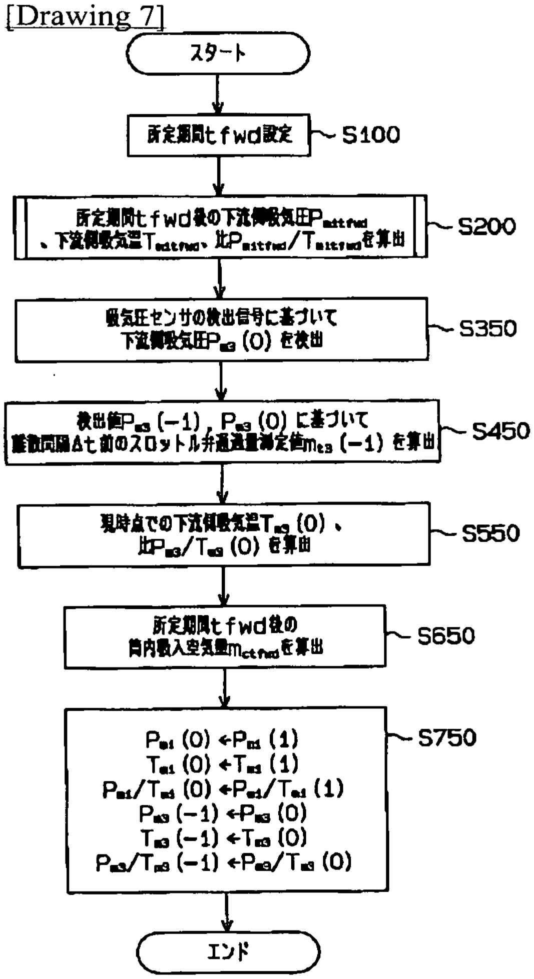


[Drawing 8]



現時点の値
初期値
t1
t2
t3
Δt
Δt

[Drawing 7]



スタート
S100
S200
S350
S450
S550
S650
S750
エンド

[Translation done.]